WHAT IS CLAIMED IS:

1. An apparatus for changing the pressure of a fluid flow, the apparatus comprising:

a plurality of lifting elements spaced from each other in a cascade, each said lifting element having an airfoil cross-section that provides lift as fluid travels relative thereto; and

a device for directing the fluid into an inlet of said cascade,

wherein at least one of said cascade and said device varies a parameter of the flow relative to each said lifting element in repeating cycles to cause the flow relative to each lifting element to begin to separate from said lifting element and then reattach thereto during each said cycle.

2. An apparatus as in claim 1, wherein said cascade comprises an axial flow impeller and said lifting elements comprise a plurality of impeller blades arranged around a hub capable of rotating on an axis.

3. An apparatus as in claim 2, wherein:

said device comprises a stator with a plurality of stator blades arranged around said axis upstream of said impeller; and

said parameter is a flow angle at which the flow is directed to said impeller, each said stator blade being oriented at a predetermined turning angle for circumferentially varying said flow angle above and below an angle of attack at which each said lifting element experiences steady-state stall.

4. An apparatus as in claim 2, said device includes a second axial flow impeller having a plurality of impeller blades arranged around said hub, said second impeller being upstream of said first-mentioned impeller and mounted for rotation on said axis in a direction opposite the direction of rotation of said first impeller; and

said parameter is a flow angle at which the flow is directed to said first impeller, each said blade of said second impeller being oriented at a predetermined turning angle for circumferentially varying said flow angle above and below an angle of attack at which each said lifting element experiences steady-state stall.

5. An apparatus as in claim 1, wherein:

said device includes a centrifugal impeller having a plurality of impeller elements arranged around a hub capable of rotating on an axis for directing the flow from said impeller into a diffuser;

said cascade is disposed at an outlet of said impeller; and

said parameter is a flow angle at which the flow is directed to said cascade, each said impeller element being oriented at a predetermined exit angle for circumferentially varying said flow angle above and below an angle of attack at which each said lifting element experiences steady-state stall.

6. An apparatus as in claim 1, further comprising an axial flow device wherein:

said lifting elements are arranged around a hub capable of rotating on an axis;

said device includes a second plurality of lifting elements having an airfoil cross-section arranged in a second cascade around said hub; and

each said airfoil in said second cascade has a predetermined geometric property that varies circumferentially around said second cascade, said property including at least one of lifting element turning angle, airfoil configuration, and distance between adjacent said lifting elements.

7. An apparatus as in claim 6, wherein:

said first-mentioned cascade includes an axial flow impeller and said lifting elements comprise a plurality of impeller blades arranged around a hub capable of rotating on said axis;

said second cascade includes at least one of (i) a stator with a plurality of stationary blades and (ii) a second axial flow impeller having a plurality of impeller blades mounted for rotation on said axis in a direction opposite the direction of rotation of said first-mentioned impeller; and

said parameter is a flow angle at which the flow is directed to said first-mentioned impeller, each said blade of said second cascade being oriented at a predetermined exit angle for circumferentially varying said flow angle above and below an angle of attack at which each said lifting element experiences steady-state stall.

8. An apparatus as in claim 7, wherein:

said first-mentioned axial flow impeller comprises a propeller for generating thrust used to propel a body through said fluid; and

said geometric property cyclically varies in a predetermined manner to minimize variations in thrust in the direction of said axis and moments transverse to said axis during each revolution of said first-mentioned impeller.

9. An apparatus as in claim 8, wherein:

said propeller comprises 2MJ propeller blades, M being an integer greater than 1 and J being an integer greater than or equal to 1; and

said second cascade introduces M cyclical variations in said flow angle around the circumference of said propeller.

10. An apparatus as in claim 9, wherein said propellers blades are skewed.

11. An apparatus as in claim 9, wherein said axial flow impeller comprises a rotor of a device selected from the group comprising an aircraft propeller, an aircraft propeller enclosed in a duct with said second cascade, a marine propulsor, and a marine propulsor enclosed in a duct with said second cascade.

12. An apparatus as in claim 6, wherein:

said axial flow impeller comprises a rotor of a device selected from the group comprising a fan of a turbofan jet engine, a compressor of a gas turbine, and a turbine of a gas turbine;

said second cascade includes a stator with a plurality of stationary blades; and

said parameter is a flow angle at which the flow is directed to said impeller, each said stationary lifting element being oriented at a predetermined exit angle for circumferentially varying said flow angle above and below an angle of attack at which each said lifting element experiences steady-state stall.

13. An apparatus as in claim 6, wherein said device includes a plurality of stages, wherein:

each said stage includes said first cascade and said second cascade, said first cascade including an axial flow impeller with said lifting elements comprising a plurality of impeller blades arranged around a hub capable of rotating on said axis and said second cascade including a stator with a plurality of stationary lifting elements arranged around said axis; and

flow exiting said outlet of said axial flow impeller of one said stage is directed to said stator of a stage downstream thereof.

14. An apparatus as in claim 1, wherein:

said device includes a second plurality of lifting elements having an airfoil cross-section arranged in a second cascade around said hub; and

each said airfoil in said second cascade has a predetermined geometric property that varies circumferentially around said second cascade to vary said flow parameter, said geometric property each said airfoil being adjustable to optimize the change in pressure provided by the apparatus at each of different operating conditions of said apparatus.

15. A method of controlling the pressure of a fluid flow, the method comprising the steps of:

providing a plurality of lifting elements spaced from each other in a cascade, each said lifting element having an airfoil cross-section that provides lift as fluid travels relative thereto;

directing the fluid into an inlet of said cascade; and

varying a parameter of the flow relative to each said lifting element in repeating cycles to cause the flow relative to each lifting element to begin to separate from said lifting element and then reattach thereto during each said cycle.

16. A method as in claim 15, wherein said parameter is at least one of the magnitude of the velocity of the flow entering said inlet of said cascade, the direction of the velocity of the flow entering said inlet of said cascade, and the swirl in the flow entering said inlet of said cascade.

17. A method as in claim 15, wherein:

said cascade comprises an axial flow impeller and said lifting elements comprise a plurality of impeller blades arranged around a hub capable of rotating on an axis; and

the number of said cycles is selected to provide a reduced frequency $O(1) > k > 0.1$ for all sections of each said blade over a predetermined operating range of said impeller, k being defined as follows:

$$k = \left(\frac{M\Omega}{V}\right)\left(\frac{c}{2}\right)$$

where k = reduced frequency, M is said number of said cycles per revolution of said impeller, Ω is the impeller angular velocity in radians/sec., c is the chord length in feet of the impeller blade airfoil section being considered, and V is the average total velocity in ft./sec. of the air flow approaching the blade.

18. A method as in claim 17, wherein:

said directing step is implemented by a stator with a plurality of stator blades having airfoil cross-sections arranged around said axis upstream of said impeller;

said impeller blades have a predetermined cross-section that exhibits steady aerodynamic stall when flow approaches said blades at an angle above a steady-state stall angle; and

said parameter is a flow angle at which the flow is directed to said impeller, each said stator blade being oriented at a predetermined turning angle that varies said flow angle circumferentially around said axis from 10° below to 20° above said steady-state stall angle.

19. A method as in claim 18, wherein said stator blades are oriented at predetermined turning angles that vary said flow angle circumferentially around said axis from 5° below to 15° above said steady-state stall angle.

20. A method as in claim 18, further comprising the steps of:

setting $K = O(1)$, selecting an impeller geometry to set c and V, and selecting a design point for said impeller to set Ω;

calculating M according to the equation $M = (2Vk)/(\Omega c)$; and

rounding M to the nearest integer.